Emotional experiences of preservice science teachers in online learning: The formation, disruption and maintenance of social bonds

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Abstract
The enactment of learning to become a science teacher in online mode is an emotionally charged experience. We attend to the formation, maintenance and disruption of social bonds experienced by online preservice science teachers as they shared their emotional online learning experiences through blogs, or e-motion diaries, in reaction to videos of face-to-face lessons. A multi-theoretic framework drawing on microsociological perspectives of emotion informed our hermeneutic interpretations of students' first-person accounts reported through an e-motion diary. These accounts were analyzed through our own database of emotion labels constructed from the synthesis of existing literature on emotion across a range of fields of inquiry. Preservice science teachers felt included in the face-to-face group as they watched videos of classroom transactions. The strength of these feelings of social solidarity were dependent on the quality of the video recording. E-motion diaries provided a resource for interactions focused on shared emotional experiences leading to formation of social bonds and the alleviation of feelings of fear, trepidation and anxiety about becoming science teachers. We offer implications to inform practitioners who wish to improve feelings of inclusion amongst their online learners in science education.

Keywords: emotion · sociology of emotion · isolation · social bonds · online learning · science teacher education

Learning to be a science teacher is a situated social practice that is steeped in emotion (Bellocchi et al. 2014). As the following quote from an online learner in our study of preservice science teacher education illustrates, this emotionality is not restricted to face-to-face encounters:

> [I feel] a mix of *excitement* and *trepidation* at launching myself into a new career path, *fear* and *excitement* at the thought of myself teaching in front of a [high-school science] classroom…, *overwhelmed* by what I still need to learn, feelings of *isolation* at being an online student and wishing I could be present at the lecture! (Student blog post, 2013, emphasis added)

This quote captures the diverse range of emotions that can be experienced by preservice science teachers studying online. Emotions are multi-dimensional phenomena that involve social, cultural, biological and neurological dimensions represented in language through the use of emotion labels (Thoits 1989) such as *fear* and *excitement* (Turner 2007). Face-to-face and online learners are likely to share experiences of fear and excitement about changing career paths and teaching high school science students. They may feel overwhelmed by the steep learning curve, and feel isolated (Kwon, Han, Bang, and Armstrong 2010). Notwithstanding, these feelings are likely to be exacerbated for online learners who have fewer options for interpersonal communication than their face-to-face counterparts. One aspect of online learning that is likely to affect feelings of isolation—or the absence of social bonds—is theorized to be the lack of physical co-presence of interaction participants that reduces the possibility of individuals to become caught up in the emotions and actions of others (Collins 2004).

Science education researchers including Alberto Bellocchi, Stephen Ritchie, Kenneth Tobin, Donna King, Maryam Sandhu and Senka Henderson (2014) and Stacy Olitsky (2007) have shown that the quality of learning experiences and uptake of science symbols (e.g., chemical concepts, laboratory materials, equations) depends partly on favourable encounters and transactions that are emotionally entraining between teachers and students and students and students. With the rapid development and expansion of online learning as seen with the uptake of Massive Open Online Courses by millions of students worldwide (Kop 2011), the need for research on student emotions in online contexts is paramount. Online modes of study offer both practical and theoretical challenges for understanding the learning experiences of preservice science teachers. Pragmatic challenges to the quality of social interaction, related to the asynchronous mode of delivery, and the lack of stimuli, such as visual and audio recordings, can reduce the experiences of online learners. More specifically, the inability to engage students in science through demonstrations and laboratory or field-work through study by correspondence reduces the discipline specific teaching strategies that are known to be effective with face-to-face learners (Bellocchi et al. 2014). These same issues pose challenges to theoretical accounts of the elements that foster successful interactions and social bonds between students and students and the professor and students. Inhibition of particular forms of interaction can impact on the experiences of online learners and lead to feelings of isolation.

We attend to these issues in this study by investigating the experiences of online preservice science teachers who were exposed to strategies and technologies designed to replicate the experiences of face-to-face students. Research findings produced in this study are used to offer suggestions for improving online learning interactions in science education and provide future directions for research on

emotion in online learning focused on reducing feelings of isolation.

The present study extends previous research about feelings of isolation in online learning (Zembylas 2008) and the efficacy of science demonstrations (Bellocchi et al. 2014) for engaging preservice science teachers studying online in three ways. Firstly, we attend to issues of isolation by discussing the role of online interactions and video lessons on emotions that support, maintain and disrupt social bonds. Secondly, we investigate whether the modeling of science demonstrations can elicit similar emotions and learning experiences for online learners as other studies have established for face-to-face learning and thereby foster a sense of group cohesion. Thirdly, we interpret interactions in an online environment through related theoretical lenses to those used to study face-to-face interactions by Stacy Olitsky (2007) and Catherine Milne and Tracey Otieno (2007) in high school science classes in the United States of America (USA), and our recent work in Australian (Bellocchi et al. 2014) and Bhutanese science teacher education classes (Rinchen, Ritchie, and Bellocchi 2015).

In the context of an online postgraduate degree program for preservice secondary science teachers, the purpose of the study was to investigate what elements of the online learning experience led to different emotional experiences and how these were related to formation, maintenance and disruption of social bonds. Next, we outline our sociological framework on emotions and interaction rituals that informs the analyses presented in the study and literature in science education that is conceptually relevant to this study.

Framing interactions, social bonds and emotion for interpreting online learning

The issue of isolation arising from the opening student statement and its pervasiveness in online learning (cf. Zembylas 2008), points to the need for students to establish strong connections with others in order to experience learning in a positive way. These connections, or social bonds, experienced by interaction participants and the ensuing feelings of social solidarity with a group are mediated by emotions (Turner 2007). During a focused encounter, the emotions expressed and felt by interaction participants are integral factors to the formation, maintenance and disruption of social bonds. This has implications for the level of attachment that individuals feel towards symbols, such as concepts, and the group that assembled initially to share those symbols (Durkheim 1915/1965).

Interaction ritual theory focuses on the feelings of confidence, or emotional energy, that people develop from focused exchanges (Collins 2004). Based on this theory, if people attend to a common object, such as a science artefact (Olitsky 2007), then there is potential for shared mood to develop. Participants will experience a sense of awareness of one another's action, including body movements, facial movements, vocalizations, and emotions. As they become aware of one another's awareness, a state of single-mindedness forms within the group where the focus of attention becomes more salient to individuals than their sense of self. Transported by the collective effervescence formed during such a social situation through vocalizations and body or facial movements, the individuals feel heightened levels of emotional energy (Collins 2004). Because these feelings of group effervescence and individual emotional energy tag the object on which attention was originally focused, the object serves as a symbol of the encounter. In future encounters or during an individual's introspection, the object can call up the same thoughts and emotions that were attached to it in the initial situation. In the context of science teacher education,

the object of focus can be the particular teaching strategy that the group had assembled to learn (Bellocchi et al. 2014). If participants perceive an object positively, then specific emotions, such as wonder and enjoyment, become associated with it.

Interaction rituals operate at three levels to circulate valued symbols and emotions. First order rituals are those encounters where symbols are first generated or shared by a group. In these initiating situations, symbols may come to signify the group and become tagged with the common mood shared by the interaction participants. Second order rituals are ones during which individuals transport symbols and practices generated in first order rituals to other places at other times to share with different people. Third order rituals represent the internal dialogue and practices of the individual when he or she circulates the symbols and practices alone (Collins 2004). We have considered how emotional energy is derived from interactional rituals from a mutual focus on a single object or symbol in preservice science teacher education (Bellocchi et al. 2014), but the circulation in second and third order rituals has not been researched previously.

Based on interaction ritual theory, Randall Collins (2004) predicts that people will continue to seek out face-to-face communication despite the wide distribution of computer technology in recent decades. In the context of education, he posits that students and teachers will regard technological solutions to education (such as online learning) as inferior to student-teacher contact in lecture rooms due to a lack of direct feedback in the form of signs of attention and inattention and a lack of adjustment to the shared emotions of the group. We noted this earlier to some extent in relation to Michalinos Zembylas' (2008) study, and research that has reported feelings of isolation among online learners (Kwon, et al. 2010); two studies which both support Collins' argument.

Emotions in interactions

Collins did not emphasize the role that different emotions play in interaction ritual theory, choosing instead to focus his attention on the Durkheimian notion of a general "emotional" energy that is experienced by individuals. We have begun to develop closer connections between general conditions of emotional energy and particular emotions in our recent research (Bellocchi et al. 2014) by drawing on Jonathan Turner's (2007) sociological theory of human emotions. His theory offers a comprehensive conceptualization that integrates microsociological approaches, such as interaction ritual theory that focus on emotional energy, with theories of discrete emotions (e.g., happiness, anger, sadness, fear).

Emotions

In his theory, Turner synthesized a range of perspectives on emotions and emotion labels from diverse research disciplines encompassing sociology, psychology, and evolutionary biology. Based on this overarching analysis, he derived four emotion labels that are included in most other disciplinary schemes as primary emotions representing elements of human neuroanatomy: aversion-fear, disappointment-sadness, assertion-anger, and satisfaction-happiness. A large list of other labels is provided that covers different intensities of these primary emotions, such as the variants of *fear* including concern (low intensity), trepidation (medium intensity) and high anxiety (high intensity), or variants of happiness, such as content (low intensity), enjoyment (medium intensity), and joy (high intensity). Combinations of two primary

emotions produce first-order elaborations of emotion captured with labels such as *awe* (aversion-fear + satisfaction-happiness), and *relief* or *gratitude* (satisfaction-happiness + aversion-fear). A further level of classification, called second-order elaborations explains the production of *alienation* (or isolation), which results from a combination of disappointment-sadness (directed at self, other or situation), assertion-anger (directed at other or situation), and aversion-fear (at consequences for self).

Social bonds

Emotions play a role in forming and strengthening social bonds between individuals, and fostering solidarity across groups (Turner 2007). In order to avoid the disruptive forces of negative emotions on social bonds, positive and negative valences became combined to produce blended emotions that were less disruptive. These included awe, wonder, veneration, and acceptance as an example of first-order elaborations of primary emotions that support the formation and continuation of bonds. Through this combinatorial process the impact of particular (negative) emotions that undermine social cohesion, such as variants of aversion-fear, was likely to have been reduced. The second-order elaboration of emotion in his theory accounts for this because three primary emotions combine to produce a new emotion having a more positive tone. As the name suggests, alienation is not an emotion that supports bond formation or maintenance. Individuals who experience alienation show lower commitments to social structures and cultural codes than those who do not experience the emotion (Turner 2007).

Formation and disruption of social bonds is important for understanding the learning experiences of preservice science teachers because the uptake of novel teaching practices (i.e., the symbols of science teacher education) that are student-centred depends on the extent to which these practices become tagged with pleasant emotions during learning situations that are perceived to be beneficial or positive experiences. Some unpleasant emotions, such as anger and irritation, may lead preservice teachers to reject particular teaching strategies. In contrast, emotions such as enjoyment, joy and happiness are likely to encourage them to adopt the strategies in future due to their own positive experiences with them during teacher education programs based on interaction ritual theory (Collins 2004).

Evidence from research in science education that has adopted interaction ritual theory as a theoretical lens is suggestive of the potential for establishing social bonds through the application of different science classroom activities. Features of classroom interactions in high school science that involved group laughter, synchronized body movements, and dialogic patterns of talk, signal the formation or maintenance of social bonds (Ritchie, Tobin, Hudson, Roth and Mergard 2011). By studying emotions and emotional energy we can develop an understanding of the factors that foster or denigrate social bonds for online learners. Having outlined this conceptual scheme based on sociology of emotions and its applications in science education research, we now focus on science education and general education research focused on online learning and the related issue of isolation.

Technology-mediated learning and emotion

There is growing interest in science education research on learning with digital technology with a diverse set of foci, including gaming for junior secondary mathematics students (Kwah, Milne, Tsai, Goldman and Plass 2014), professional

learning communities for science teachers (McConnell, Parker, Eberhardt, Koehler, and Lundeberg 2013), and online mentoring for beginning science teachers (Bang and Luft 2014). Collectively these studies have focused on online or technology-mediated interactions and building a sense of community. One outcome from a study of two beginning science teachers found that professional development is expedited through online mentoring experiences supported by written dialogues known as threads (Bang and Luft 2014). Two experienced teacher mentors interacted with the new teachers through exchanges mediated by the threads that enabled a sharing of teaching practices they had learnt in their teacher education programs. Threads also became a site for emotionality as the beginning teachers shared pleasant and unpleasant episodes, including some failures of their own as well as from staffroom stories provided by other teachers.

Interest in fostering effective communities online is shared by other science education researchers such as Tom McConnell, Joyce Parker, Jan Eberhardt, Matthew Koehler, and Mary Lundeberg (2013) who investigated the professional development of 54 K-12 teachers in a problem-based learning project. In contrast to the asynchronous threads in EunJin Bang and Julie Luft's study, a virtual conferencing platform that enabled real-time interactions with video, audio and writing tools was used to discuss and share science teaching practices by teachers in McConnell and colleagues' (2014) study. Teachers' experiences in this learning environment were compared with those of others who engaged in face-to-face professional development. Results showed that the facilitators of the online element of the professional development sessions found discussions to be very similar to those taking place in face-to-face mode with teacher participants spending equal time participating in tasks and discussing similar issues in both modes of delivery. These authors reported that teachers who engaged in the online interactions felt that strong collegial relationships had developed within the group referring more specifically to feelings of camaraderie, social connections, and friendship that are all indications of social bond formation mediated by the technologies adopted to facilitate the professional development of teachers.

A more recent study focused on the emotional engagement of science students during interactions focused on game development, whereby real interactions were focused on applying technologies to game development (Kwah, et al. 2014). This represents the only study of technology-mediated learning that adopted related sociological theoretical frames on emotion and social interaction to ours. This investigation of gaming technology focused on development of an after-school curriculum designed for female middle school students in the US. The students and their regular classroom teachers were engaged in developing mathematics games aimed at elementary school children. The researchers introduced a curriculum focused on developing games into the program, but found that it triggered negative emotions initially for the middle school students and their teachers. By responding to these negative experiences through changes to the curriculum, the researchers were able to scaffold successful interactions focused on gaming to generate a collective climate of positive emotions. Another factor that produced unsuccessful interactions was the structure of the computer laboratory used initially in the study, which did not enable students and the teacher to be in constant visual contact. Classroom interactions improved and so did the collective emotions inferred by the researchers when the physical setting for gaming lessons was changed to one where all participants could maintain a central focus of visual attention and could see one another. One recommendation emerging from that study was the need to consider student and

teacher emotion when curriculum is developed for science and mathematics instruction. The study by Kwah and colleagues (2014) provides an example of the way in which interaction ritual theory has been applied in contexts of technology-mediated learning and curriculum design. Although understandings about the emotional arousal of teachers and students focused on technology use in a mathematics education context was provided by that study, no studies focused on preservice science teachers were identified in the literature sources.

Modes and media of communication used by university educators in online learning and writing environments can take many different forms. Little is known about how specific forms of online learning address students' needs for social interaction and inclusion (McInnerney and Roberts 2004). Furthermore, whereas there have been few studies focused on the online learning experiences of science teachers and an absence of research on preservice science teachers, there has been an extensive research focus on the emotions experienced while learning online in other educational contexts. These studies suggest that there are benefits for learning when effective connections with others are established through the use of various technologies. Effective connections and interactions have been the focus of science education research in face-to-face settings.

Interactions and emotional experiences in face-to-face science settings

Beneficial emotional outcomes such as improved engagement and willingness to adopt the chemistry symbols used in science class have been reported in studies seeking to connect emotions with learning science through demonstrations (Milne and Otieno 2007). Related research has also shown that students from disadvantaged backgrounds may be more inclined to participate in science through discussion about discrepant events, because these demonstrations provide a central focus of attention for the class and they elicit emotional reactions. Furthermore, class discussion enables students to use their own linguistic resources for explaining phenomena (Olitsky 2007).

Two of us (i.e., Alberto and Steve) have more recently established connections between preservice science teachers' emotions, collective emotional arousal—emotional climate—and the quality of learning experiences involving science demonstrations (Bellocchi et al. 2014). In that study, the use of discrepant event demonstrations in combination with predict-observe-explain strategies and role-plays about science concepts were associated with highly positive emotional climate within the class and individual emotions including wonder, joy, surprise, attentiveness, and happiness. Although the studies reviewed here have focused on emotion and classroom interaction rituals in science education, they all took place in face-to-face teaching contexts. It is not clear how interactions that transpire online elicit preservice science teachers' emotions and what role these feelings have to play with regard to common experiences of isolation or online teaching approaches.

Research strategy and preservice science context

This study was informed by a hermeneutic phenomenological methodology aligned with interpretive inquiry in science education (Tobin and Ritchie 2012). We attended to the second-order recounts of preservice science teachers' phenomenological, or first-person, experiences of emotions during online learning. As researchers, we brought our third-person perspectives to the research through

hermeneutic interpretation of data sources based on our multiple theoretical lenses informed by the sociology of emotion and microsociology.

The study took place in a one-year pre-service science education course in a large Australian university delivered over 10 weeks. Sixty-four students were enrolled including males and females from a variety of cultural backgrounds, aged 22-55 years. The different modes of study available to these students included both full time (45 students) and part time (19 students) modes. Within these two modes, delivery of course content was tailored for 16 face-to-face students (on-campus) and 48 online students (off-campus). During the five-week study period (weeks 1-5), 44 online students posted a minimum of one response in the blogging component of the course. Weekly variations in the number of student contributors to the blogs were as follows: Week 1, 21 participants; Week 2, 14 participants; Week 3, 21 participants; Week 4, 10 participants; and Week 5, six participants. These contributions amounted to 284 blog entries containing 392 emotional reports. The number of specific emotions recorded was greater than the total number of participants and total number of blog entries because students often identified a range of experienced emotions in each lecture as seen in the opening quote to the introduction of the article. It is common when using self-report techniques such as emotion diaries, for participants to report multiple specific emotions when appraising an experience retrospectively (Bellocchi 2015). Of the 392 emotional reports, there were 22 unique terms used by online learners to label their emotions out of which 12 labels were related to social bonds.

Blogging about online learning experiences

Live lectures presented by Steve for the first five weeks of the course were video-recorded and presented on the course website for online students to access on the day following each face-to-face class. Provision of lecture recordings was intended to offer experiences for online learners akin to those of face-to-face students. In combination with the weekly blogs, videos provided a simulated version of the face-to-face learning experience. During lectures one and two, the professor presented science demonstrations designed for critique by pre-service teachers. These demonstrations included modeling the use of discrepant events (Liem 1987). Course readings included science education articles in different cultural contexts (Tobin 1988), an article about interactive and engaging pedagogies by Gaell Hildebrand (1998), articles on the New Basics Curriculum and Productive Pedagogies (Hayes, Martin, Christie and Lingard 2006), and research by Stephen Ritchie, Kenneth Tobin, Maryam Sandhu, Senka Henderson, and Wolf-Michael Roth (2013) on emotional arousal in science. These articles were discussed and debated during lectures and in the blogs.

Other course activities involved viewing and discussing classroom videos that contrasted different teaching strategies, and pre-service teachers also designed concept maps. Students provided weekly feedback about their learning and emotions by writing and posting an e-motion diary or web log (blog) visible to the professor and student cohort (Mills and Ritchie 2014). After viewing the online lecture each week, students blogged their answers to the following questions: What issues/practices could influence your practice as a science teacher? How would these issues/practices be incorporated into practice? What emotions did you experience during this online lecture? The professor also participated as a contributor to the blog, responding to comments and questions.

Analyzing e-motion diary responses

Data sources for our study included 284 online posts about emotions and learning experiences. The constraints posed by emotion research with participants who are not directly observable require suitable analytical tools for interpreting specific emotional experiences. In this study, the e-motion diaries provided participants with opportunities to report their emotions in their own terms (i.e., there were no pre-assigned emotion labels). Although participants used labels that were consistent with those in sociological typologies of emotion (e.g., Turner 2007), we also needed a system of analyzing comments that did not refer to emotions through direct reference to a common label. For example, students may provide statements such as "I was upset as I watched the online recordings as I felt inadequate." Whereas there is an easily coded reference to sadness in the first part of this example in the use of *upset*, the analytical tools employed have to be adequate for coding the second part of the statement, which is not related to the list of emotion labels based on common categories available in the literature. In these cases, contextual cues were used to offer potential labels such as *fear* or low intensity *anxiety,* both of which are emotions experienced when an individual feels they have not met self-expectations, other-expectations or those relevant to a situation (Turner 2007) as is the case here.

To identify the individual emotions reported by students using unique terms, we applied open coding to the full corpus of blogs using the participant's own terms or related synonyms, yielding twelve different emotion labels. A research assistant and the three authors coded all of the entries until agreement was reached about each emotional statement and a suitable label was chosen to describe the emotional experience. To achieve this, we treated existing typologies of emotion labels in the literature as data sources to generate an emotion database.

A research assistant analyzed major works and collections about emotion research in collaboration with Alberto (i.e., the first author) to create a database that documented emotion labels as well as key elicitors and antecedents of those emotions. Texts used to create the database included the *Handbook of Sociology of Emotions* (Stets and Turner 2007), *The Sociology of Emotions* (Turner and Stets 2005), the *Handbook of Emotions* (Lewis, Haviland-Jones and Barrett 2010), the *International Handbook of Emotions in Education* (Pekrun and Linnenbrink-Garcia 2014), the *Handbook of Affective Sciences* (Davidson, Scherer and Goldsmith 2002) as well as key works from traditions aligned with our theoretical frames including Collins' (2004) *Interaction Ritual Chains*, Jonathan Turner's (2007) *Human Emotions: A Sociological Theory*, *Emotions in Education* (Schutz and Pekrun 2007), *Unmasking the Face* (Ekman and Friesen 1975) and a study by Theodore Kemper (1991). In this way, we attended to the literature by accessing emotions research from education, psychology and sociology and treating each text as a site of human social practice that has produced and reproduced understandings about emotions and, more specifically, emotion labels in accounting for sentiments of human experience. This approach avoided reductionist perspectives of inquiry on emotion by focusing on multiple classification schemes. It also enabled us to interpret students' blog responses, which were often reported without the use of stereotypical folk labels, such as happy and angry. Due to some diversity in the way emotions are labeled in the various texts, we adopted the terms used by Turner (2007) to label emotions in this study. When terms or phrases did not align directly with Turner's labels we used our database to identify related labels from other typologies.

As an example of our analysis, the statement "I felt sick in the stomach" was coded as "anxiety." We attended to these kinds of language resource used to convey either positive or negative evaluations of entities, happenings, and states-of-affair. These may be descriptions such as "I feel overwhelmed", or indirect references to emotions such as "Thinking about teaching in nine weeks is overwhelming." As a final layer to the analysis, when student accounts did not match any of the terms in our database, we identified the etymology of the words (Harper 2014) or their English language synonyms using the *Oxford paperback dictionary thesaurus and wordpower guide* (Soanes, Waite, and Hawker 2001) and matched these to Turner's labels. This system of analysis allowed us to account for every idiosyncratic case of terminology that was used by online learners to express their emotions.

Online emotions and the formation and disruption of social bonds

We report analyses to support the claim that the formation and disruption of social bonds is facilitated by video lectures generally and more specifically those focused on science demonstrations and blogging about learning and emotional experiences. Videos and blogs helped the formation of social bonds for online learners through the sharing of emotive interactional resources (i.e., vocal cues, body and face movements, emotion labels) similar to those available in face-to-face exchanges. Through the presentation of our research findings we establish that the visual and audio resources of classroom emotions enable the formation of social bonds for online learners with the face-to-face class asynchronously. Videos of science demonstrations fostered active engagement of online learners as well as a range of positive emotions. By responding to questions posed by the professor, online learners formed connections through viewing lesson recordings despite the mode of communication lack of physical co-presence. Blogging about emotions through the e-motion diary facilitated emotional attunement and formation of social bonds through the circulation of valued symbols, including emotion labels.

Specific emotions experienced during online learning

Over the course of the five weeks of video lectures, the number of emotion labels reported by participants in the study decreased. After the week 1 lecture there were twelve unique labels used to describe the emotional experiences associated with social bonds. The number of unique labels reported decreased over time as listed below:

Week 1	Anxiety, Comfort, Involved, Confident/strong, Apprehension, Overwhelmed, Isolation, Concern, Enjoyment, Fear, Uncertainty, Excited,
Week 2	Frustration, Connection, Overwhelmed, Excitement, Enjoyment
Week 3	Frustration, Unsupported, Overwhelmed, Enjoyment,
Week 4	Frustration, Lack of fear
Week 5	Excited, Connection

Other terms used by students to report their emotions that were not associated with social bonds included *engaged*, *disengaged*, *interested*, *surprised*, *depressed*, *grateful*. Of these, *surprise* is recognized as a primary emotion in some classifications

(Ekman and Friesen 1975), and *interest* is included as an emotion by some educational psychologists (Pekrun and Linnenbrink-Garcia 2014). Of all terms associated with social bonds used by preservice science teachers to explain their emotions, the following list was not identified in any of the literature sources included in our database: *attachment, engagement*, *disengagement*, and *overwhelmed*. We coded reports of *attachment* as evidence of social bonds rather than as a specific emotion because feelings of attachment, or its corollary, isolation (or alienation; Turner 2007) were related to a range of other emotions. Our detailed analyses will uncover these connections. *Overwhelmed* was one key sentiment expressed by online learners that is also elaborated in detail later due to its significance to social bond formation.

The e-motion diary data provided initial insights into emotional experiences of online learners linked to who experienced these emotions, how they persisted or changed over time, and how these sentiments were related to social bonds that ameliorated feelings of alienation. These emotion terms represent all of the labels contributed by different students. Multiple terms were often reported by individual students within a single weekly response as seen in the opening quote of our article taken from Francis' week 1 e-motion blog, which included trepidation, fear, excitement, being overwhelmed, and isolation.

The student generated terms not commonly recognized as emotion labels were coded using our emotion database. In this way, we applied conventional labels to refer to them. The words that did not align to specific labels included, uncertainty, confidence/strength, comfort, unsupported, connected and involved. *Confidence* and *strength* are associated with boldness to take action in a situation. These terms refer to general states of emotional arousal called emotional energy (Collins 2004). In the English language, *comfort* is a synonym for the emotion *serene,* which is a low-intensity variant of satisfaction-happiness (Turner 2007). The terms *unsupported, connected,* and *involved* all signal relations between participants within a group, and thereby indicate the condition of social bonds and group solidarity. More specifically, the word *unsupported* indicates the lack of or disruption of bonds, whereas the terms *connected* and *involved* represent intact bonds and feelings of personal status as a group member. Although none of these latter terms are recognized as emotion labels, the fact that they are all associated with social bonds and social solidarity provides a direct connection with emotion (Scheff 1990). That is, emotions are mediators of social bonds and solidarity, so it is likely that the participants did not make a distinction between experiencing bonds through emotions, such as joy, and more generally through enhanced feelings of emotional energy, such as strength and confidence, when bonds had formed or when they were experienced.

One other descriptor of emotions used by the students, *overwhelmed,* did not match any emotion labels in the database. Based on the etymology of this word in English, it acquired the meaning in the 1520s of bringing [something or someone] to ruin (Harper 2014) and nowadays it also refers to being overpowered and "to have a strong emotional effect on [someone]" (*Oxford paperback dictionary thesaurus and wordpower guide* 2001). These meanings point to a sensation that is unlike other emotion labels such as *fear* and *excitement* because overwhelmed has a more general character and one can feel overwhelmed *with* emotions like anger, frustration, joy, love as well as feeling generally overwhelmed without a reference to a distinct emotion. Phrases such as these that are used commonly in English indicate that *overwhelmed* can be used to modify and state the extent to which one feels a specific emotion or it can be used as a standalone proxy for general overpowering emotional

feelings as in the phrase "I feel overwhelmed" or, less directly, "I was awash with emotion." These examples suggest that the general feature of emotion that is represented by the term *overwhelm* (and it's adjectival form *overwhelmed)* is the intensity or emotional energy with which a specific or non-specific feeling is experienced or perceived. Having framed the specific emotions experienced by students in this study more generally and clarifying some idiosyncratic terms used to report emotional experiences related to social bonds, we now relate the emotional reports to students' online learning experiences.

Alienation, social bonds and solidarity. Data sources like the opening quote in the article, and statements from other students such as "[I was not] able to participate actively" framed the focus of our study initially on feelings of alienation experienced by students and the potential for social bonding in online learning. Alienation is an important issue in online learning because the willingness of learners to uptake science concepts and pedagogies is undermined by emotions, like alienation, that disrupt social bond formation (Turner 2007). In Turner's classification of emotions, the label *alienation* is used to describe feelings of isolation or low sociality. Alienation is a second-order elaboration of three primary emotions including disappointment-sadness (at self, others, or situation), assertion-anger (at others or situation) and aversion-fear (at consequences for self). These three emotions combine when an individual is in a situation where he or she cannot withdraw from an encounter where they do not feel strong social bonds during the flow of interactions.

Whereas three students directly used the term "isolation" (which is a synonym for alienation) in their emotion diaries others referred to the concept of alienation, or it's opposite, a social bond, in a number of ways. An example of the direct use of the term *isolation* in the diary was represented in the following quote extracted from Rahel's blog: "it was great to see my lecturer; it gave me a sense of strength and confidence. I didn't feel so *isolated* or as anxious." The sense of strength and confidence recorded by Rahel indicates feelings of positive emotional energy, which is a key outcome and ingredient for social bond formation and maintenance. Nerida's e-motion blog contained an example of an indirect reference to isolation when she stated "it was nice to have some personal contact." This suggests that seeing other people through the video recording provided experiences of social contact. Examples were also found where specific emotions associated with social bonds were reported as evidenced when Matilda posted that she was "excited to be part of the group." Her statement indicates her feelings of connectedness with others, which she associated with the emotion label "excitement."

In contrast to the positive experiences already mentioned, Patrick stated that he felt like an "outsider" initially due to the quality of the camera work in recording the lesson. His use of the word "outsider" indicates a lack of membership to *the group* which in this case is the face-to-face class seen in the video. The words people use to express ideas in classroom conversations circulate the science symbols that represent group membership in a science teacher education class (see Olitsky 2007 for examples in high school settings) and the broader science education community (cf. Collins 2004). Lack of access to these symbols impedes bond formation because individuals cannot tag valued concepts that represent group membership with emotion. Patrick's alienation was resolved, he claimed, once the camera had been shifted to frame the professor centrally in the field of view. Although this did not improve the sound recording, it allowed visual cues of the speaker to be captured and made available for online learners. Students continued to report alienation throughout the

five-week period. For example, one report in week 4 mentioned that online learners lacked the discussion opportunities experienced by face-to-face students. Such statements reveal broken bonds or a lack of bonds due to the absence of opportunities for interaction.

For Francis, her initial reports in week 1 of alienation were not resolved until the fourth week of blogging interactions. Our opening quote in the article was taken from her first e-motion diary entry where she indicated not only feeling alone, but also a desire to have the same learning experience as the face-to-face students. This desire and the feeling of alienation then became frustration in the second and third week because she could neither participate in classroom activities, nor access the same resources that were distributed to face-to-face students. Similarly, Rosie reported in week 3 that she felt worried (i.e., concern; low intensity aversion-fear) because she thought she had missed out on a reading to which Steve referred in the video.

Watching lesson videos led students to feel less supported at times because they could compare their condition with that of the face-to-face learners. Such comparisons set up expectations about the learning situation experienced by online students and when these expectations were not met this resulted in the activation of emotions related to medium intensity assertion-anger, that is *frustration* (Turner 2007). It was not until the fourth week that Francis reported positive changes of her emotions as shown in the following response:

> My emotions during this lecture [week 4] were far more positive. I did not feel fear just excitement and interest. I think I'm getting in the right head-space now in relation to studying again after such a long time and seeing my future potential as a teacher. (Francis, March 2013, week 4 e-motion diary)

The fear to which Francis is referring was also captured in her week 1 blog. In fact, she used two labels related to aversion-fear: *fear* and *trepidation.* She attributed her trepidation to starting a new career path in teaching and her fear was directed at teaching children during her field placement in eight week's time. The week four e-motion diary entry above shows that her earlier feelings were subsiding in favor of *excitement* and *interest* (an emotion in some classification schemes; for example, Pekrun and Linnenbrink-Garcia 2014). Her excitement was related to the possibility of adopting some innovative teaching strategies in her future classes based on those presented in one of the course readings.

Francis' comments reveal an important aspect of learning to be a science teacher from an interaction ritual perspective. The stated desire to adopt the teaching strategies presented in the course indicates a willingness to appropriate the symbols of the science teacher-education class, which she has now connected with the emotion *excitement.* This emotion label is a synonym for the high-intensity variant of satisfaction-happiness. By reflecting in this way, her introspective account is evidence of a third order ritual in which science education symbols are circulating because when she writes her blog response she is physically separated from other preservice teachers and the professor. Francis' comment also supports the possibility that she will form second order rituals with future students in high school science classes based on the stated intentions to enact the teaching strategies that were associated with a high intensity emotion.

The last comment in Francis' week 4 blog excerpt above about being "in the right head-space" for studying could help to understand her earlier reports of

alienation and the desire to work in face-to-face mode. Head-space is a vernacular term used commonly to refer to one's mindset or view/belief of self (Dweck 2006/2012). Her earlier comments in weeks 1-3 are interpreted as indications of her mindset as not being focused or positive about studying through online mode. What her comments indicate is that her own expectations of study, represented by her reference to an initial mindset, were not matched by the learning experiences during the initial weeks. As Turner theorizes, when an individual's expectations for self or situation are not met, then negative emotions arise, and positive emotions result from expectations being met. Francis' self expectations as a learner may have changed over time regarding her study, evidenced by the claim of being in the right head-space in week 4, and this opened the way for positive experiences and the associated emotion of excitement.

Another relevant aspect of Francis' week 1 blog to the focus of this study was that it led to the formation of group bonds between her and the online learners. When she first described her fear and trepidation, Janine responded to the post with the following comment:

> Just letting you know that you are not alone in that *emotional boat* Francis, you described my thoughts and feelings exactly! (Janine, week 1 e-motion diary, emphasis added)

Janine's comment invites the formation of a social bond and emotional attunement with Francis by acknowledging the same emotional experiences through the phrases "you're not alone" and "my thoughts and feelings exactly." An inadvertent outcome in this research of asking the online students to record an e-motion diary that was available for viewing by their peers was that it provided the emotional modality of communication that is normally accessible through face-to-face interaction but less available in asynchronous digital communication. Without the open sharing of emotions in this way, it would have been unlikely for students to share their feelings thereby limiting the opportunities for a social bond to form.

Further evidence of the formation of social bonds through shared emotions in the diary came from Nerida's blog in which she felt a "degree of contentment to [be] part of a group of 'real' people" who were all "in the same boat." The idiom "in the same boat" implies that people find themselves in a similar difficult or unfortunate circumstance (Ayto 2009). We also saw partial reference to this idiom in Janine's blog when she referred to the "emotional boat" in response to Francis. The example from Nerida's contribution also opens a different perspective on formation of bonds when she referred to "real people." That is, the video contained the images and sounds of other students and the lecturer forming a basis for human connection. These interactional resources made online exchanges real for Nerida and led to her feelings of connectedness. Steve also had an important role to play in the early exchanges related to Francis' blog because he acknowledged her initial feelings as normal for preservice teachers. The response generalized the feelings to all preservice science teachers past and present thereby forming another point of shared experience between the current online learners, and those of the past who were implied in Steve's normalizing statements. His comment further enhanced the sense of togetherness that was developing between the online learners by establishing a point of solidarity with a broader community. There was no specific reference to individual students Steve had encountered in the past, so he created an image of a *generalized other* with whom students could relate.

Although Nerida and Janine's statements are the most direct examples in our data set of shared emotionality, they were not the only cases observed. Other students used words or phrases in their e-motion diaries that indexed the feelings of previous bloggers, and this also indicated the sharing of emotion and formation of social bonds around these emotions. As Regina stated in her blog pertaining to her nervousness (i.e., moderate aversion-fear), "I believe I am not the only one who feels this way." Regina does not connect her comment with any specific person, recreating the image of the generalized other who has the same feelings just as Steve did in his response to Francis.

Eliciting factors associated with emotions and social bonding. The formation of social bonds was focused on particular emotional reports offered by online learners. We now attend to the eliciting factors for the emotions that enabled bond formation. *Fear*, *trepidation* and *anxiety* were emotions associated with preservice science teachers' considerations of having to teach high school students in nine weeks from the beginning of their course. Related to these feelings were notions of the overwhelming task of learning about student-centered teaching approaches before having to implement similar strategies during field placement at the end of the course. One exemplary quote from a student blog indicates their feelings and the associated antecedent factors to which it was attributed:

> The main emotion felt during the lecture, and this week has been *overwhelmed*. Like most of people I spent 12 years at school and thought I had some grasp of what 'good' teaching was. Now I see I have a great deal to learn and only eight weeks until my first prac [field placement] (Janine, week 1 e-motion diary, emphasis added)

Janine references prior schooling experiences as a resource for her conceptualization of what constituted *good teaching* before experiencing the examples of student centered teaching approaches offered in Steve's class. Her initial confidence about perceptions of high quality instruction was disrupted by a science demonstration presented by Steve that was captured in the week 1 video. In discussing the demonstration and also a range of possible teaching strategies with the face-to-face students, a long and diverse list of pedagogies was created and represented on the classroom white-board. Steve's efficacy in presenting the demonstration and the list of pedagogies are likely to have formed the voluminous "wave" of knowledge and skill ("a great deal to learn") that Janine experienced as overwhelming. Awash with these feelings, Janine then directed these into her future practices as indicated by her statement "Now I see" projecting her emotions into the temporal element within which these actions may need to be performed during her first field placement at the end of the nine-week course.

Other students associated the same factors that Janine found overwhelming with other emotion labels. In relation to the prospect of having to teach high school students so soon Patrick reported *trepidation* (moderate intensity aversion-fear; Turner 2007), Reagan said she felt nervous (i.e., anxious; moderate intensity aversion-fear), whereas Samuel felt daunted (i.e., fearful). There were also direct uses of the labels *fear* and *anxiety* associated with the volume of learning and the short time-frame in which it was to be achieved. The sharing of specific emotions like fear, anxiety and trepidation as well as general sentiments of being overwhelmed and nervous (i.e., anxious) formed the basis for attunement and social bonds to emerge.

This finding reinforces the problematic nature of classifying emotions as positive or negative because although the discrete emotions mentioned may have felt unpleasant for the individuals initially, sharing them led to the positive outcome of emotional attunement. For this reason, attribution of valence, represented as positive and negative charges, to particular emotions must be considered carefully in each context where they arise rather than treating positive and negative charges as some aspect of the ontological character of emotions.

Feelings of fear, trepidation, anxiety and being overwhelmed expressed by students were understandable because during the first lecture, Steve brought to the fore the stark reality of the short time span between the preservice teacher's commencement of the course and the field placement scenarios in which they would immediately be immersed in nine-weeks. Steve referred to examples from his own teaching experiences and his knowledge of contemporary classrooms to elaborate potential scenarios that the preservice teachers may face during field experience.

A further element of the instruction that contributed to these feelings was the science demonstration of discrepant events that Steve had modeled for his class and captured in the video lecture. Numerous online learners reported that they had never been taught during high school through such engaging strategies as the discrepant event demonstrations. Furthermore, Steve had deliberately delivered it in a way that was inefficient so that he could invite the critiques of his teaching style from the preservice teachers and improve on the instruction in week 2. The purpose of this aspect of his instruction was to model a system of giving constructive feedback to lesson presenters because the class assessment scheduled for the end of semester involved preservice teachers presenting microteaching lessons. Part of that task required the audience to give constructive feedback to peers who were presenting their lessons. Steve's modeling of appropriate ways to deliver constructive feedback provided both a way of normalizing suitable approaches for delivering a critique to peers and also modeling an effective approach for preservice teachers to consider in their own pedagogy. That is, to invite their high school students in future to critique lessons openly and in constructive ways. This social practice produced a classroom structure that, when witnessed for the first time by online learners, created anxiety because they would not only have to present lessons to a group of peers for assessment but they would have to do so through engaging, student centered pedagogies and invite the critique of their audiences on the quality of their teaching. It is understandable that as their introductory lecture to science teaching, the combination of these factors appeared overwhelming.

Other student accounts attributed emotions to a wide range of elements of the online learning experience. For example, Patrick reported his anxiety (trepidation) in relation to the upcoming field placement. In this way, his emotions were directed at two aspects of the learning experience that were not related directly to the video lecture. Nerida also provided a blog response that listed emotions associated with different aspects of her learning experience as a whole rather than being focused on the lecture as seen in this blog extract:

> I felt *happy* at times during the lecture when something funny was said. I felt *relieved* when some issues about field placement were explained. I also felt *nervous and got butterflies in my stomach* when I realised how soon it was until we would be in the classroom. I also felt some degree of *contentment* to

> know I was part of a group or "real" people and that we were all in the same boat. (Nerida, week 1 e-motion diary, emphasis added)

Her statement captures emotions related to situational aspects of the lecture that were separated temporally throughout the two-hour video recording. Such complexity in emotional reports that cover long timeframes of an individual's experiences are unsurprising, because emotions are elicited by so many events that occur on a moment-by-moment basis during interactions in addition to the range of expectations that people bring to encounters. Over time we noted that the number and types of emotion labels reported had decreased in our week 1-5 list. In part, this decline may be attributed to the fact that the lecturer became aware and responded to many of the concerns raised by online learners during the first two weeks, such as improving video sound quality, repeating face-to-face student responses, directing students to available course resources, and directly responding to their initial fears and anxieties by normalizing these feelings. In this way, his responsiveness to student feedback on the blogs may have contributed to the amelioration of some sources of negative emotions.

The kinds of emotional experiences discussed so far were not shared by all participants because a number of them felt *excited* about their career change and the new teaching approaches to which they were being exposed, some experienced *enjoyment* of the course readings, and *enlightened* (not classified as an emotion according to our database) by the science demonstrations modeled by Steve in weeks 1 and 2. Individual students also reported a mixture of emotions like Francis did in week 1. Reports of multiple emotions are likely when students are asked to appraise a situation like a learning experience that unfolds over long periods of time such as at the end of a two-hour lecture video (Bellocchi 2015).

Science demonstrations as sites for solidarity online. Videos of science demonstrations presented in weeks 1 and 2 influenced student feelings of *enjoyment, excitement, engagement, curiosity,* and *admiration, confidence* and *comfort*, of which the latter two are forms of emotional energy conducive to social bond formation. This reinforces previous reports of confidence of online learners that were linked to experiences of success and enjoyment, especially when interactions were related to "strategies to promote the learning of their [future] students" (Tobin 1998 p. 156).

One of the science demonstrations, the week 1 discrepant event, involved the science concept of air pressure. Two large (1 Liter) glass jars had a large plastic bag attached to the openings. One jar had the plastic bag pushed completely into the jar except for a section that was sticky taped to the mouth of the jar creating a complete seal so no air could enter the jar. The second jar had another plastic bag attached outside of the jar by also being taped to the mouth so no air could enter or leave the jar from outside. The plastic bag on this second jar was partly swollen with air. The discrepant event occurs when one attempts to pull the bag from the first jar out of it, when compared to trying to push the bag into the second jar. A face-to-face student volunteer was invited to participate in the demonstration by pushing and pulling the two bags then reporting his experiences to the class. Steve scaffolded the feelings of excitement through his instruction by building tension in the room as he asked the face-to-face students to explain what occurred when the volunteer pulled or pushed the bags.

Online students reported emotions similar to those experienced by face-to-face students in other studies (Bellocchi et al. 2014) and some of them also reported

shouting answers at their computer monitors in response to Steve's demonstration questions. Although this is one-way communication from the shouting student to the screen without any instant and direct feedback from face-to-face participants, it shows a level of entrainment with the demonstration and the face-to-face participants because the playing of the video is "real-time" relative to the online learner. That is, as the demonstration is unfolding moment-by-moment on their screens they are actively interacting with Steve and the face-to-face class. Our finding suggests that physical co-presence may not be a necessary ingredient for the formation of entraining and successful interactions for online learners contrary to what Collins predicted about asynchronous communication involving technology (see also Tobin 1998). It is important to add a caveat to this statement.

These interactions that lack physical co-presence help us to explain how online learners can experience sentiments of confidence and comfort leading to feelings of connectedness with the face-to-face group. Participation in classroom interaction by shouting answers is *real* participation; some elements of face-to-face encounters are still available to online learners in the way of a single focus of attention created by the demonstration, the body and facial movements of Steve and the volunteer, the facial movements and body movements of the face-to-face learners, and in particular the sounds which also convey emotion. All of these interactional resources are present in the video recording and they provide a substrate for the formation of shared experience and shared emotion. These emotional modalities afforded online learners many of the ingredients that enable social bonding situated within face-to-face encounters. As predicted by IRT, these sights and sounds are entraining and contagious leading to heightened levels of emotional energy in individuals which is manifested as feelings of confidence and boldness to take action in adhering to the group symbols by shouting answers involving science concepts.

Sharing symbols of science teacher education

As we have seen in previous work, in the context of science education (e.g., Olitsky 2007) and science teacher education (Bellocchi et al. 2014), emblems that represent group interactions include science symbols (e.g., equations), science artifacts (e.g., demonstration materials), ideas about student-centered pedagogy such as discrepant event demonstrations (Bellocchi et al. 2014), and classroom science debates (Bellocchi et al. 2013). Evidence of the generation of shared symbols for the online learners in the present study was found in blog comments (thirty-five comments overall) that reported intentions of these preservice teachers to adopt the pedagogies presented by Steve in their future practices. Furthermore, one of the preservice teachers, Matilda, explored the pedagogies with her own children at home before having the opportunity to practice them in a high school class during field placement. This evidence supports the claim that some preservice teachers were prepared to adhere to the symbols of the group beyond the initiating rituals.

Interactions in the weekly blogs and when students watched lecture videos constitute first order interaction rituals where symbols were initially shared and emotionally tagged. When Matilda, practiced these symbols with her children, she established a second order ritual by circulating the symbols with different people at a different time and place from the original classroom ritual. Because multiple preservice teachers reported the intent to adopt the group symbols, this creates a basis for group membership and social bonds between the online learners and Steve, as well

as the broader communities including the face-to-face class and science education generally.

Disruption of social bonds and solidarity. There was one factor reported by the preservice teachers in weeks 1-4 that worked against the formation of social bonds. This was the quality of the sound recording on the videos that was associated with frustration as noted in the example from Patrick's blog noted earlier. The recording set-up included a microphone worn by Steve to capture his speech. However, due to his position typically at the front of the class, the responses to his questions provided by face-to-face students were not clear. During lectures, particularly long responses by students, this created long intervals of silence in the video recording where the camera was directed at Steve so neither sound nor image of the speaker was captured. Even though the students were likely to have been accessing other resources during these periods (Tobin 1998), the absence of some visual and audio resources could have prevented online learners from becoming entrained in the class interactions thereby interfering with the formation of social bonds.

Students reported feelings of being disconnected with the face-to-face group throughout weeks 1-4 despite the improvements to video sound quality as Steve attended to the student feedback. This suggests that the quality of social bonds experienced by online learners depends on the extent and form of participation they engage in. Perhaps those students who yell at their monitors feel like they are part of the group because they are interacting even though there is no feedback about their contributions through physical co-presence with other students. Francis, the student who expressed on-going alienation, participated regularly in blog discussions about the weekly topics, so this form of interaction should have provided one avenue of bonding with other online learners but was not enough for her to feel connected to the group. Even though some learners found the poor quality of sound recording distancing, these same students reported feelings of being connected to the face-to-face group because of the use of video lectures throughout the five-week period. One of the students offered a suggestion in the blog responses that the professor should repeat face-to-face student responses to his in-class questions. To some extent, Steve's implementation of this idea relieved the issue of online learners not being able to access relevant content of talk; subsequently, students reported being grateful for his actions.

Understandings and Implications for Social Bonds in Online Learning

Videos of classroom transactions and e-motion diaries were associated with emotions such as *alienation, anxiety, frustration, trepidation, fear, enjoyment,* and *admiration* resulting from the interactional milieu offered by asynchronous communication and sharing of sentiments online. The most important aspect of the e-motion diary was that it provided a space for emotion sharing to occur and this enabled social bonds to form around aspects of the learning experience. These bonds assisted those students who initially felt alienated.

Videos, and in particular those focused on science demonstrations, provided a different set of interactional cues from the e-motion blogs, including a site for mutual focus on the demonstration materials and presenter and shared sights and sounds that represented classroom emotions of the face-to-face group. The videos also enabled one-way interactions between online students and the classroom group. These sets of verbal and non-verbal features of interaction afforded online learners with entraining

experiences that also led to the resolution of alienation, and fostered emotional engagement with the face-to-face group and Steve.

Elaborating the bonds formed through videos of science demonstrations

As we have noted in other studies of preservice science teachers (Bellocchi et al. 2014) in Australia and Bhutan (Rinchen, Ritchie and Bellocchi 2015) and as reported in studies with high school science students in the US by Olitsky (2007) and Milne and Otieno (2007), science demonstrations create a resource that focuses the attention of the class and produces shared emotions and emotional energy within the group. Similarly, we found the online students expressed excitement and enjoyment towards the demonstration in the present study even though they viewed the lecture video alone (i.e., without physical co-presence). This finding extends previous research which was focused on face-to-face teaching and learning (Bellocchi et al. 2014) because here we have an asynchronous viewing of the demonstration. We extend previous findings through our present research by not only identifying increases in emotional energy but also detailing the specific emotions, including *enjoyment*, *admiration*, *excitement* and *curiosity*, experienced when videos of demonstrations were broadcast for online learners. The present study shows that videos of science demonstrations can foster bonds and interactions in a similar way as they do during face-to-face interactions. This teaching strategy could be altered for future research by segmenting pre-recorded science demonstrations and including pauses where online learners have time to answer questions for themselves before progressing to a new segment where the explanation of the demonstration is taken further. We note that to do so would require considerable editing post-recording and this would increase lesson preparation time for professors.

Blogging through e-motion diaries facilitates bonds

As Zembylas (2008) argued, online learning environments need to be emotionally supportive to enhance students' learning experiences, which may be one step towards relieving feelings of alienation that prevail in these situations (Kwon et al. 2010). Our study makes a contribution to understanding one way in which social bonds can be created online through sharing of emotions in e-motion diaries. The type of bond formed between online learners through blogging was different from the feelings of solidarity that students experienced with face-to-face learners through the video lectures. This is due to the structure of interactions made possible by the two different modes of learning.

The e-motion diary provided access to the emotions of others in written form through sharing of emotion labels or general emotional experiences, replacing the typical interactional cues that would lead to exchanges of feelings between group members in face-to-face transactions. Despite the lack of synchronous interaction mediated by physical co-presence, the emotions expressed by individuals and, more importantly, the responses of others to those emotional accounts created the conditions necessary for emotional attunement and fostered sentiments of connectedness within this online community. Our findings indicate that online learners could potentially experience a *greater* sense of bonding and solidarity than face-to-face students because through the use of video lectures in combination with e-motion blogs, online learners can connect and become attuned to two groups (i.e., face-to-face and online groups) that are geographically and temporally separated. In

contrast, face-to-face students formed bonds only within the class and not with the online learners in this study. A new investigation would be required to ascertain the validity of this possibility.

Another potential follow-up study would be to create activities that all students have to complete online regardless of mode of attendance. This would form a bridge between the two communities potentially increasing the number of bonds between participants. Whereas studies have reported that online learning can be an isolating experience (Zembylas 2008), our study suggests that this depends on the resources made available to online learners for forming social bonds by facilitating emotional attunement. We encourage professors to invite students to blog about their emotional experiences as a way of enabling social bonding between online learners and to supplement this with video lectures that enable feelings of solidarity to a second community of face-to-face learners and the professor. It would be interesting in future to explore whether or not using the blog for face-to-face learning activities leads to further integration of online and face-to-face learners, and builds even stronger communities and solidarity between these two groups of learners. A second aspect of the efficacy of blogs used by Steve was to have preservice teachers discuss the potential use of teaching strategies in their future practices. In our study, blog questions directed in this way generated third-order introspective rituals, which led to recirculation of science education symbols.

A different approach for enhancing social bonds from the aforementioned one could involve science education professors sharing their own emotional journeys as former teachers to provide an image that online learners and face-to-face leaners can relate to initially through shared feelings but can also project onto their future selves as science teachers because they have before them a person who has potentially managed initial feelings of fear, trepidation, anxiety and being overwhelmed to go on and become an effective science teacher. In this study, Steve's in-class discussions where he shared classroom experiences of his teaching days provided a resource for all students that formed the initial feelings of being overwhelmed, but also served as examples of practice or what preservice teachers could experience in their own future classes. In this way, the preservice teachers could begin to consider how they would address similar situations. Although this kind of instruction may serve as an initial source of fear or anxiety, it also provides a realistic account of what is to be expected in some cases and begins the process of presevice teachers' reflections on what they would do in similar circumstances.

Collectively, the outcomes reported in this study suggest that as the kinds of interactional resources available in face-to-face encounters become replicated in online environments, this leads to the formation of social bonds, solidarity and peer support to assist in the alleviation of emotions such as fear anxiety and feelings of being overwhelmed and alienated. More specifically, the sharing of emotions through e-motion diaries is a useful way to encourage social bonding.

Recoding of emotions in an online e-motion diary during learning episodes has important implications for the way in which online learning experiences are designed and conducted. Asking online learners to share willingly their emotional experiences of studying a course can lead to the formation of social bonds through shared experiences and peer support. These accounts can also provide instructors with feedback that can be used to modify instruction, as Steve did, as the course progresses if they identify specific emotional experiences that are not conducive to learning but that can be easily addressed through some intervention. It is worth noting that Steve also had a role to play in interacting with students about their emotional experiences

as reported in the diary. By normalizing the feelings, his comment immediately established a social connection with the students and the wider education community because Steve was drawing on his extensive experiences with teaching preservice science teachers to inform his current students. His comments not only acknowledge the feelings expressed but they connected them to a vast network of people who presumably overcame these feelings and became science teachers successfully. This serves to ensure the current students that they too have the capacity to overcome these initial emotions and progress towards success both in the course and in the career of science teaching. Steve's practice illustrates an important role that professors need to play in blogging interactions if they are to invite their students to express their emotions in a similar way. Feelings that are likely to deflate students and lead to ongoing isolation should be alleviated immediately by the professor through similar discussion of the common aspects of these emotional reports by past students.

Theoretical matters and future directions for emotion and online learning

Our study has successfully applied interaction ritual theory and perspectives from sociology of emotion to understanding the experiences of preservice science teachers online. Whereas others have interpreted face-to-face interactions focused on game-based learning through interaction ritual theory (Kwah, et al. 2014), our study provides a novel contribution to emotion research in science education by extending the theoretical framework to explain asynchronous interaction and emotion online. Despite Collins' pessimistic outlook towards digital communication as inferior to face-to-face encounters, we have found that when some elements of social interaction such as emotional expressions and visual and vocal cues are included in asynchronous interaction, then social bonds can form, and some of these are developed around valuable science education symbols like different student centered pedagogies. Future research could explore what effect removing videos, where the professor or face-to-face class is visible or audible, has on online learners' emotions. For example, if lecture recordings have only slides and a voice-over but no image of the professor and these are combined with an e-motion diary, we can ask: "does this reduce the learning experience for online students?" For universities with program structures like ours that included face-to-face and online learners in the same courses, another interesting investigation would be to compare the emotional reports of online and face-to-face students during science demonstrations, and another possibility is to have face-to-face students participating in online activities with online students to see whether this approach facilitates social bonds for face-to-face students with online students.

For preservice science education research and practice, our findings in relation to the circulation of symbols in second order rituals is another important contribution made in this study. Second order rituals represent the uptake of specific pedagogies taught in first order rituals in the teacher education class and the intent to subsequently apply the same symbols in other settings like high school science classes. Similarly, the third order circulation of symbols when individual preservice science teachers are alone is important to the ongoing engagement in second order rituals in their future classes, and for their individual planning to include valued science pedagogies. As Collins notes, it is possible to witness second order rituals by observing interaction participants in social settings other than those in which particular symbols initially gained their relevance. Although it is more challenging to access third order rituals, reflective accounts of personal experiences that require introspection can provide access to this level. To some extent, the blogs used in our

study can provide access to intent of adopting symbols in second and third order rituals. Future studies with preservice science teachers could focus on second and third order rituals to understand better how teaching practices that are tagged with emotions during first order rituals are re-circulated in other contexts. Research of this kind could inform practice and policy related to the uptake of educational reform.

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Stephen M. Ritchie is Dean of the School of Education, Murdoch University, Australia. Steve’s research has focused mostly on classroom issues that relate to teaching and learning science. He currently conducts research on the emotional engagement of students in science classes as they become more scientifically literate. He is also interested in the emotional experiences of beginning science teachers and the quality of pre-service science teacher education.